

Semi-analytic Modelling of the Low-density Intergalactic Medium

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Broad Idea

Motivation: understand the baryonic structure formation in the Universe.

Significant portion of **baryons** at $1 < z < 5$ found in the **intergalactic medium (IGM)**.

Probed through **QSO absorption spectra** (mainly Lyman- α lines).

Advantages of using Lyman- α lines: **(i)** large dataset; **(ii)** unbiased sample; **(iii)** no star formation or shock -- easier to model.

Theoretical models: absorption lines arise from **density perturbations** in a smooth IGM; the temperature is set by **photoionization equilibrium**.

We present a model which predicts the **transmitted flux** of the QSO spectra, given the **background cosmological model** and **parameters related to the IGM**.

The Model

Dark Matter Linear
density field



Smoothing at small scales

Baryonic Linear
density field



Lognormal assumption



Photoionization equilibrium



Effective equation of state

HI density field



Baryonic Non-linear
density field

$$\rho_{\text{NL}} \propto e^{\delta_L}$$

Optical depth
&
Transmitted Flux

Model Parameters:

Background cosmology (fixed to be flat **ΛCDM** model with $\Omega_m = 0.4$, $\Omega_\Lambda = 0.6$, $h = 0.65$, $\Omega_8 = 0.79$, $n = 1$)

Temperature (T_o) at the mean density

Slope (γ) of the effective equation of state [$T = T_o (\rho / \rho_o)^{1-\gamma}$]

A combination of baryon density (ρ_B) and local ionizing radiation (J_{-12}), given by $f = (\rho_B h^2)^2 / J_{-12}$

Transmitted flux statistics used for comparing with observations:

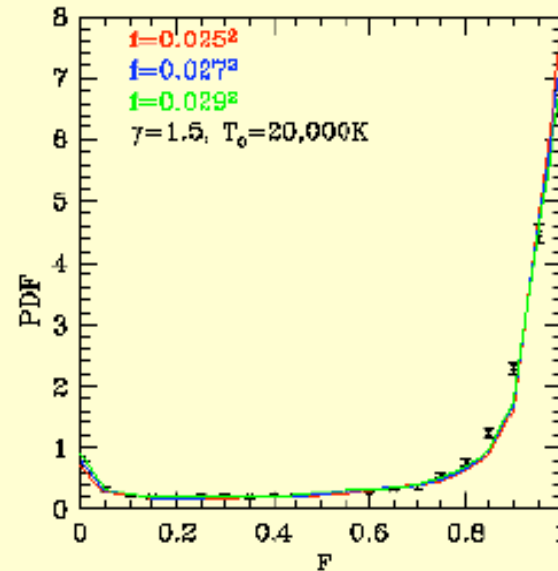
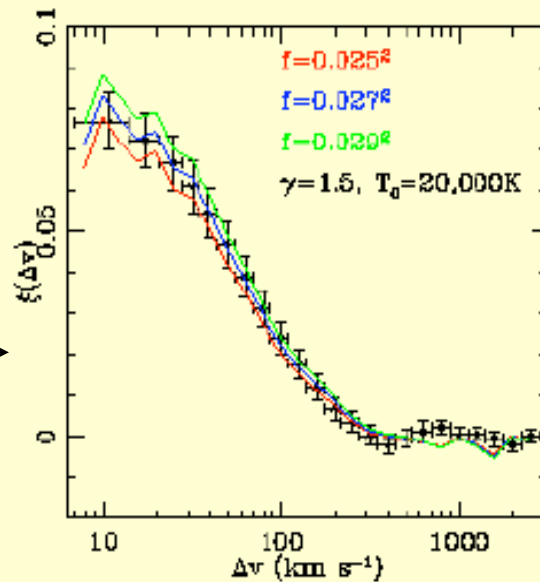
Probability distribution function (PDF)

Correlation Function

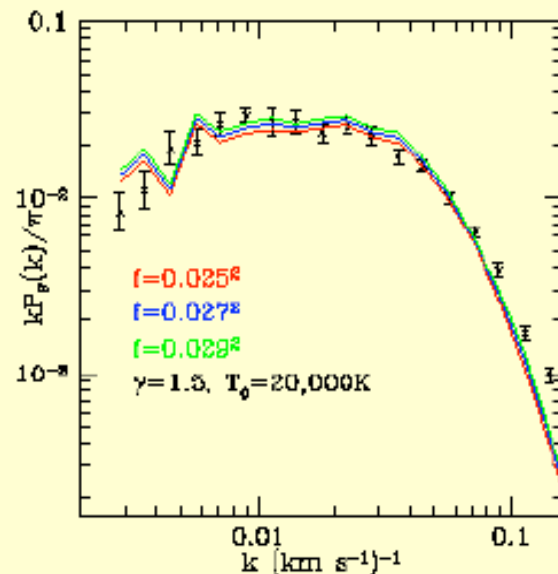
Power Spectrum

Comparison between model results (curves) and observations (points with error-bars)

Correlation
Function



PDF

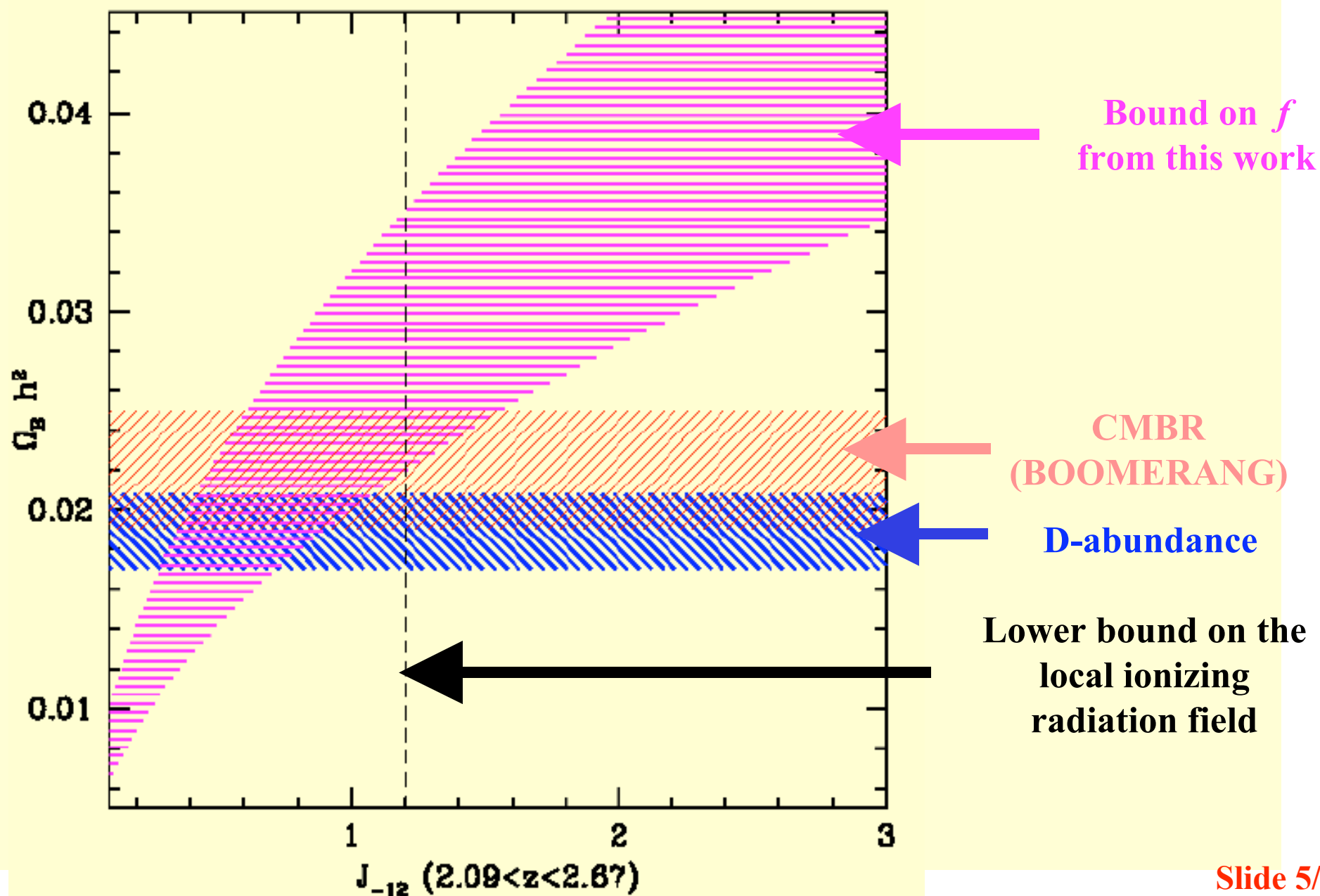


Power
Spectrum



Excellent match with observations!
This model can be used for
constraining parameters

Comparison of bounds on $\Omega_B h^2$ obtained from this model with those obtained from CMBR and BBN



Summary:

Semi-analytic model of the IGM based on **(i) lognormal assumption** for the baryonic non-linear density field, and **(ii) photoionization equilibrium**.

Used transmitted flux statistics to **constrain parameters** related to the IGM by comparing with observations (in the redshift range $2.09 < z < 2.67$).

Constraints obtained from this model agree with those obtained from other studies.

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References:

Choudhury, Padmanabhan & Srianand (2001), MNRAS, **322**, 561.

Choudhury, Srianand & Padmanabhan (2001), ApJ, **559**, 29.